Space Weather Technical Forecast

Issued on Tuesday, 14 February 2023 at 12:21 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further M-flares (R1/R2 Radio Blackouts) likely, with a Slight chance of isolated X-flares (R3 Radio Blackout). Slight chance of G1/Minor Storm on Days 1 and 2 (14-15 Feb). Active fluence declining.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity was Moderate during the period, with two low-level M-flares, both originating from AR3226 in the northeast. There are currently 12 sunspot regions on the visible disc. The most noteworthy region AR3226, has continued to mature after rapid development, and may contain a small Delta spot although limited imagery makes this difficult to assess at present. However, there are also two larger regions approaching the northwest limb, AR3213 and AR3214. AR3213 has been a source of flaring but is now rotating off the disc and is no longer fully visible. AR3214, although moderately sized, has been fairly stable. AR3217, the source of an X-flare on the 11th, has now faded significantly. Other regions appear relatively small and simple at present.
No Earth-directed CMEs have been observed in available imagery during the last 24 hours. A CME seen recently in imagery travelling northeast is unlikely to be Earth directed.

Solar Wind / Geomagnetic Activity: There has been an outage of solar wind data since 13/2330 UTC. However, a weak CME arrival was observed starting around 13/1705 UTC. Wind speeds were at ambient levels, varying between 330-370 km/s. The density was predominantly at average levels. Total IMF, Bt, was weak but jumped from 2nT to around 5nT. The north-south component varied weakly between +3/-2 nT. The Phi angle was predominantly positive (away from the Sun). Geomagnetic activity was Quiet (Kp 0-2). After 13/2330 UTC, it seems likely that largely ambient conditions continued, perhaps with some continuing weak CME effects, as the geomagnetic activity remained Quiet.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at background levels. The high energy electron flux (greater than 2MeV) measured by GOES-16 was at Moderate to High levels, with a peak of 5450pfu at 13/1725UTC. The associated 24-hour electron fluence rose above the Active threshold. The fluence at 14/0001 UTC was 1.35e8 integrated pfu.

Four-Day Space Weather Forecast Summary
Solar Activity: Solar activity is likely to remain Moderate, with further M-class flares. There is a slight chance of becoming High with any isolated X-flare.

Solar Wind / Geomagnetic Activity: Earth has experienced weak CME effects recently. There is also the possibility of a further weak CME giving a glancing pass later on Day 1. Otherwise, there are no significant coronal holes in the forecast at present, so the solar wind speed is likely to remain at largely ambient levels. There is the possibility of a weak High Speed Stream (HSS) pushing wind speeds to slightly elevated levels on Day 4, but with low confidence.
Geomagnetic activity is therefore expected to be mainly Quiet to Unsettled, perhaps rising to Active to G1/Minor Storm on Days 1 and 2 with any weak CME effects, and perhaps Active on

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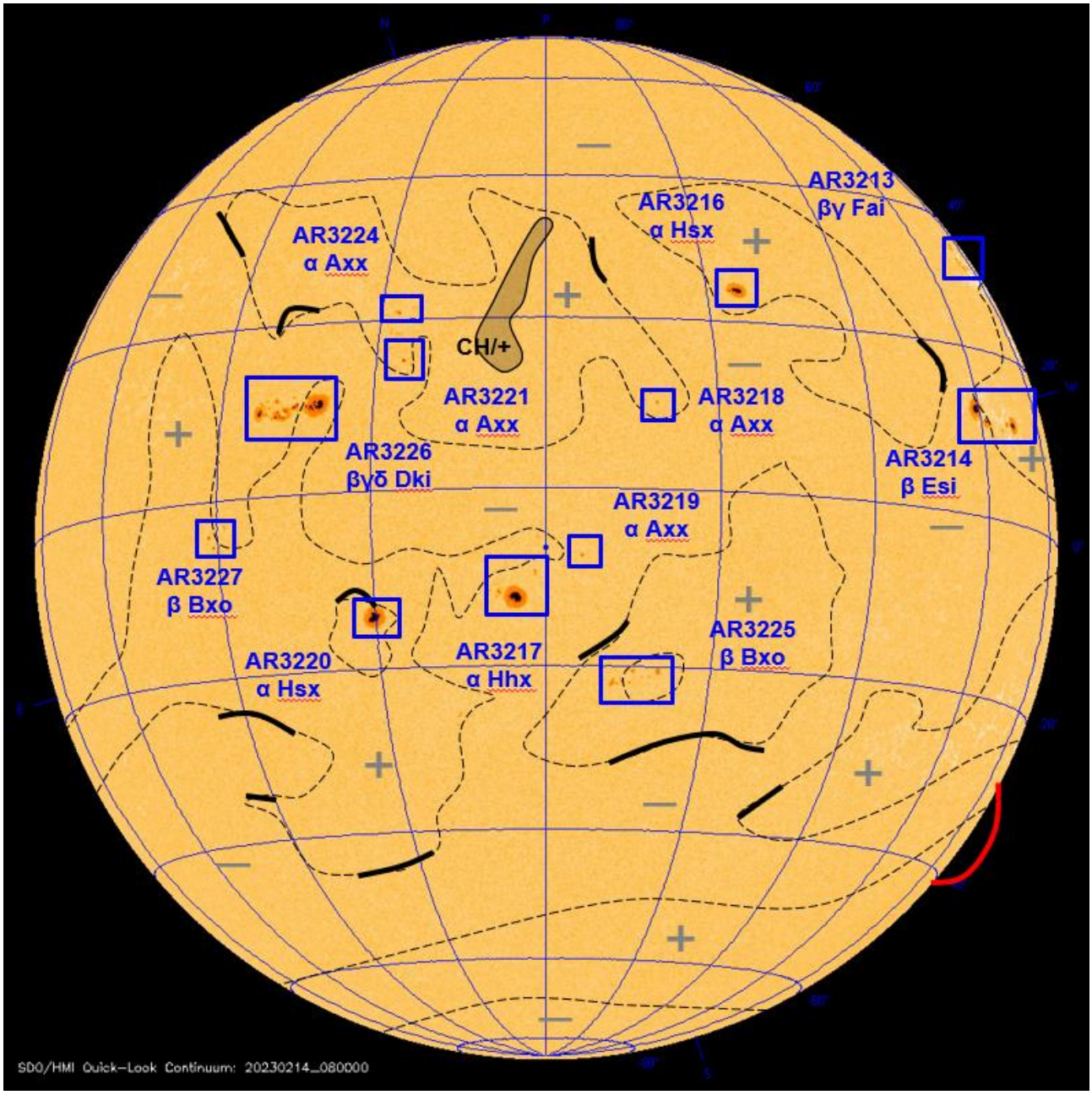
Day 4 if we see a weak HSS.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels, but with a slight chance of exceeding S1 in response to any significant flares. High energy (greater than 2 MeV) electron flux is expected to be Moderate to High on Day 1 (14th), but on an overall declining trend through the period. The associated 24 hour fluence is currently above the Active threshold (1e8 integrated pfu), but likely decreasing below Active from Day 2 (15th).

Figure 1. Solar Analysis Valid 14/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The anticipated 11th Feb CME appears to have reached L1 starting around 13/1705UTC, with weak effects on solar wind parameters thus far. There is also the chance of a further CME giving a glancing pass later on Day 1. However, effects from this CME are also anticipated to be mainly weak.

Otherwise, there are no significant coronal holes in the forecast at present, so the forecast for the coming few days mainly concerns any further glancing CME effects. Assuming these remain mostly weak, the solar wind speed is likely to remain at largely ambient levels. Enlil is suggesting a High Speed Stream (HSS) arrival on Day 3 (16 Feb), and on the previous rotation there was a HSS on the equivalent of Day 4 (17 Feb). However, imagery suggests any coronal hole is very weak and less obvious than the previous rotation, so it is unlikely to give significant wind speed increases. It is possible that wind speeds may reach slightly elevated levels on Day 4, but with low confidence.

Geomagnetic activity is therefore expected to be mainly Quiet to Unsettled, perhaps rising to Active to G1/Minor Storm on Days 1 and 2 with any weak CME effects, and perhaps Active on Day 4 if we see a weak HSS.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	5	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
10/2148	Partial	Filament	SW	420	14/1800 UTC	Low chance of glancing blow

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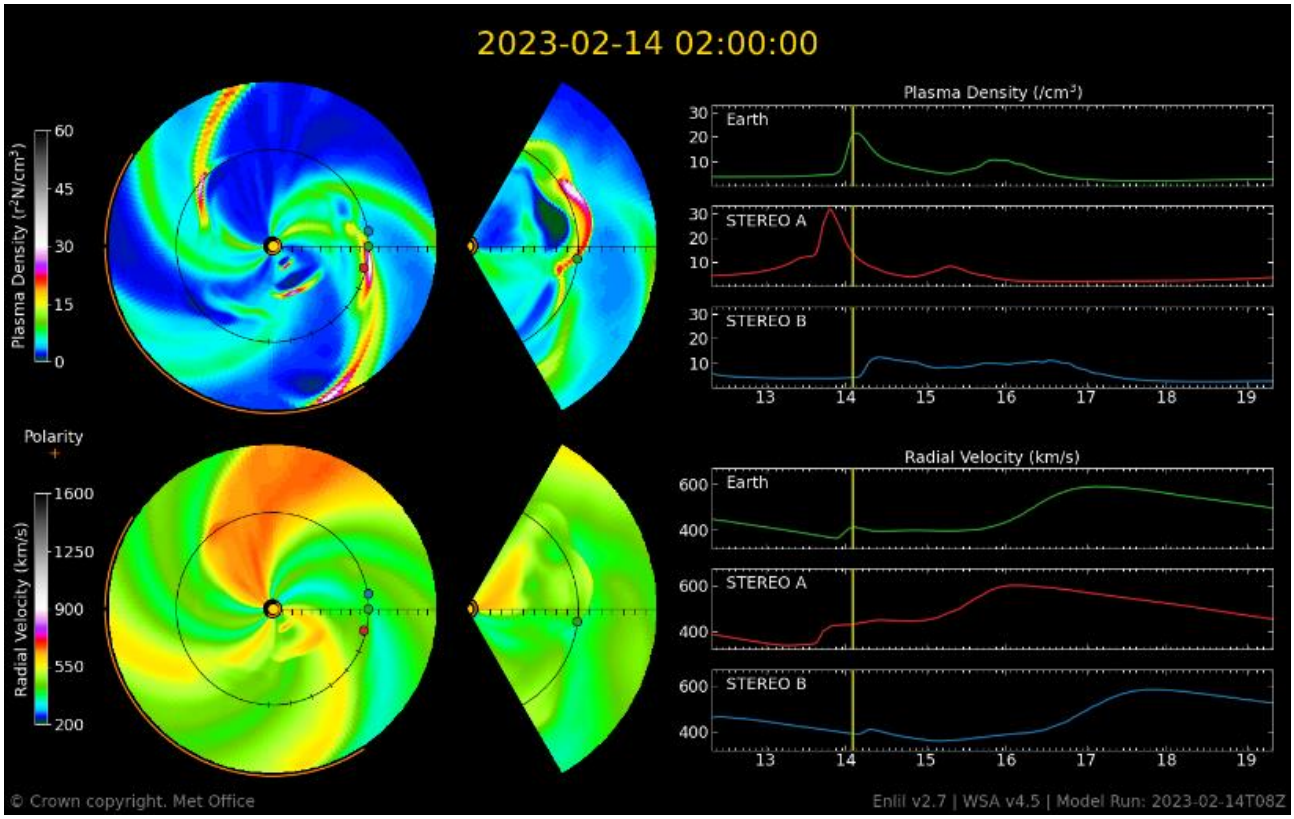
Figure 2: MOSWOC Enlil. Generally ambient winds predicted at first, but the increase shown on the 16th is likely to be too high and too soon.



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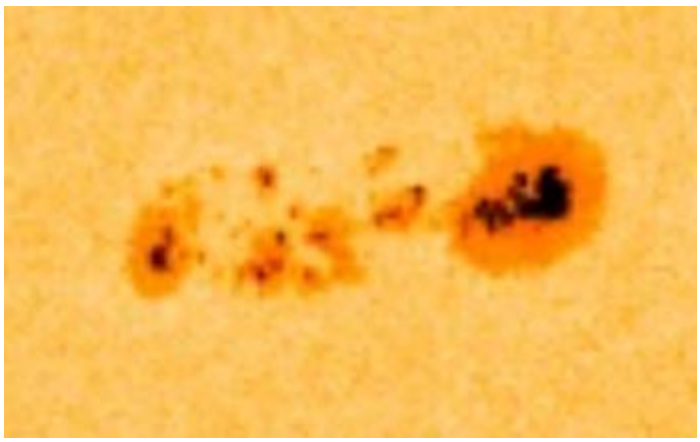
Radio Blackouts - X-Ray Flares:
Solar activity has been Moderate in the last 24 hours, with two M1 flares from AR3226 (Dki/Beta-Gamma-Delta) in the northeast quadrant.

There are currently 12 sunspot regions on the Earth-facing disc. The most noteworthy region is AR3226, which has continued to mature after rapid development, and may contain a small Delta spot although limited imagery makes this difficult to assess at present. However, there are two larger regions approaching the northwest limb, AR3213 (Fai/Beta-Gamma) and AR3214 (Esi/Beta). AR3213 has been a source of flaring but is now rotating off the disc and is no longer fully visible. AR3214, although moderately sized, has been fairly stable. AR3217 in the southeast, which had previously been the source of significant flare activity, has continued to decay and is now classed as Hhx/Alpha. Most other regions are either small and magnetically simple or relatively stable and unremarkable.

Further M-class flares are likely, with a slight chance of isolated X-class flares. A slight reduction in risk is indicated as some larger regions rotate off the west limb, and far side seismographs and STEREO-A EUV imagery are suggesting that no significant regions are likely over the next few days.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	50	50
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: AR3226, which has developed rapidly in the last couple of days.



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Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. No notable high energy proton response has been observed from recent M-flares. Any further significant flares may increase count rates, with a slight chance of exceeding the S1 level. AR3213 (Fai/Beta-Gamma) will rotate off the disc late on day 1 (14 Feb) with a gradual decline in proton risk thereafter. AR3217 has now decayed significantly in the last couple of days and is therefore unlikely to present a significant risk of a proton event in its current configuration.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	10	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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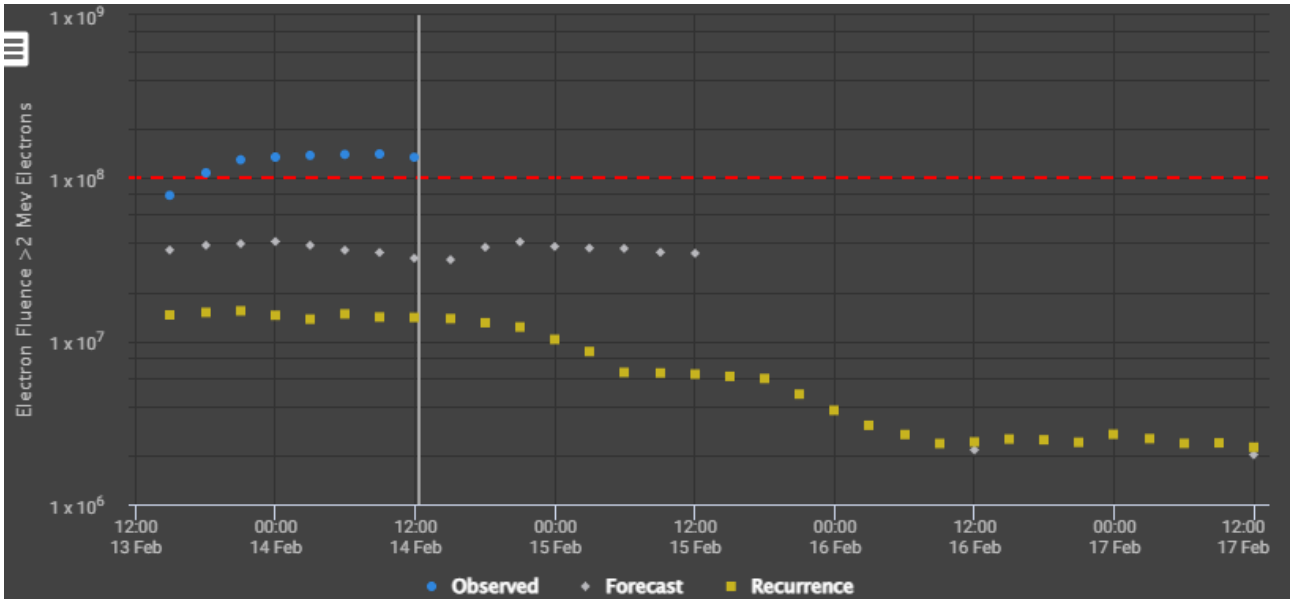
High Energy Electrons Event (≥ 2MeV):
The high energy (greater than 2 MeV) electron flux at GOES-16 was at Moderate to High levels, with a peak of 5450pfu at 13/1725UTC, although it has dropped off in recent hours. Solar wind speeds have been mainly at background levels, although there is evidence of weak CME interaction at present, and there is the possibility of a further glancing CME later on day 1 (14th). Wind speeds are likely to remain ambient or perhaps slightly elevated through this period, with further charging unlikely. Therefore, flux levels are expected to drop through the period, although the timing of any fall is low confidence.

The associated 24 hour fluence has risen just above the Active (1e8 integrated pfu) level, and is now significantly above both REFM and recurrence predictions. There is uncertainty as to how significant these passing CME effects may be on the electron counts. However, considering the period as a whole, an overall decrease is expected, with fluence levels probably falling back below the Active threshold from day 2 (15th).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	50	20	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: MOSWOC REFM, which is significantly under-forecasting fluence levels at present. That said, a drop in fluence over the coming days seems most likely.



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